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DETECTORS FOR OTTO FUEL II.

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Otto Fuel II is a liquid monopropellant torpedo fuel, containing as the main ingredient 1:2 propylene glycol dinitrate. This ester is toxic, both by inhalation and by skin absorption. A threshold limit value of 0.2 parts per million in air (that is, 1.3 milligrams per cubic metre of air) was originally established by the National Academy of Science and this value was also specified as the ceiling value for PGDN.

Several changes in the TLV for PGDN have been proposed. Most recently, on 13th May 1981, the American Conference of Governmental Industrial Hygienists TLV committee proposed a change to 0.05 ppm in the TLV. The ceiling value remains at 0.2 ppm.

The British Institute of Naval Medicine has formed a working group on Otto Fuel toxicity, and agrees these values and has recommended protective clothing, special ventilation and continuous monitoring of the atmosphere in workrooms where Otto Fuel is exposed.

The American Mk 15 Otto Fuel Detector is used for continuous monitoring, and it is ideal for this purpose. But more was needed. Because the ceiling value is well below the equilibrium vapour concentration in air at normal temperatures, we need quick warning whenever the ceiling value is exceeded. We also needed a reliable method of checking whether cleaned torpedo components were indeed free from all traces of Otto Fuel, because these components go to a mechanical assembly area where no special precautions are taken against toxic risks.

The Royal Armament Research and Development Establishment had invented, designed and manufactured an explosives detector, to respond to minute traces of nitroglycerin based explosives. This detector was tried and found to respond efficiently to Otto Fuel without modification, and so was introduced for use in the Royal Naval Armament Depots, but it was not completely successful. It was mechanically robust, because it had been designed to be used by soldiers, but it was too sensitive, and the gas-valve assemblies did not have a long, leak-proof life.

This basic design was re-engineered by Messrs Graseby Dynamics of Watford, England, to produce a commercial explosives detector. The special requirements of Otto Fuel detection in Royal Naval Armament Depots were discussed with this firm by Mr David Butt of DSTAS Armament Engineering Division and the Author, and an especially desensitized model was produced, specifically for this work.

The Requirement

The detector was required to be reliable, and to respond to Otto Fuel II vapours with defined sensitivity. An alarm was needed at the ceiling value, and visual indication of the presence of fuel vapours at lesser concentrations.

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Great sensitivity would be a disadvantage. Traces of fuel vapour are powerfully adsorbed by plastic surfaces, and false alarms would be given by a very sensitive detector held close to any electric cable or similar component.

Ideally, the detector should respond to no other chemical. In particular, chlorinated hydrocarbon solvents should produce no response from the instrument.

The detector should be light, portable, robust and not be too costly. It should be able to work continuously for a minimum of six hours.

The PD2F Detector

The detector contains a special platinum-coated filament, whose surface will adsorb contaminants present in the surrounding gas.+

A powerful suction pump draws gases through the detector. In the sampling mode, a mixture of the sample diluted with clean air and primary argon is drawn over the cold filament. Contaminants in the sample are adsorbed on to the filament surface. At the same time, a small flow of secondary argon passes through the electron capture detector, to keep it clean and maintain a constant electrical signal.

In the purging mode, the suction is stopped. Both argon flows continue, but the fluidic valve closes and so the sample and air mixture is no longer drawn into the instrument. The primary argon flow passes over the filament, while the secondary argon flow continues to pass through the detector.

In the detection mode, the filament is electrically heated. The contaminants selectively desorb one by one, and at a particular instant the valve near the detector opens. The secondary argon flow now passes directly to waste, while the primary argon, together with any desorbed traces of Otto Fuel from the filament passes through the electron capture detector. It is fortunate that nitrate esters generally, and Otto Fuel in particular, bind very firmly indeed to the filament and so desorb last, and are easily separated from other materials. This sampling, purging, and detection sequence is repeated every $3\frac{1}{2}$ seconds.

The electron capture detector is a tube containing a radioactive source. Tritium, adsorbed onto copper foil, provides a copious source of low-energy electrons which do not present a detectable radioactive hazard outside the body of the tube itself. A central electrode, suitably biased, will collect some of the electron flow. Any impurity present in the gas passing through the detector will capture electrons and so diminish the current; the detector is very sensitive but not at all specific. But only the strongly adsorbed contaminants are admitted to the detector.

Electronic circuits amplify the output from the detector, and compare it with the steady state current when pure argon is flowing through the detector. Any difference is measured and presented as a numerical readout on the instrument display. An audible alarm can be set to function at any desired level.

A sealed, nickel-cadmium battery pack provides electric power to work the pump and the electronics. A small cylinder charged to 2500 lbs/sq in contains the argon which is used as a carrier gas and a purge gas. Both the battery and the gas supply can work the detector for at least six hours. The entire equipment weighs 10 Kg.

It is important to check each day that the instrument is working, by holding it near a contaminated article. These checks are done and recorded daily, before work starts.

Experience has shown that six-monthly calibration is required to maintain adequate performance. The detector is checked by exposing it to a known concentration of Otto Fuel vapour in air. This is produced at a calibration centre by bleeding a known volume of Otto Fuel at a steady, known rate from a motor-driven microburette into a measured, constant air flow. The concentration chosen for this checking is 0.2 ppm, the ceiling value, and the detector is adjusted to read 20 at this concentration. Coarse adjustments are effected by altering the size of the metering jets which admit diluent air to the sampling head, and fine adjustments by alterations to the level of inputs to the electronic gates which process the signal.

The digital read-out is not directly related to the concentration of fuel which is sensed by the detector. The digital output is a continuous, monotonic function of the input concentration, but is not directly proportional to it. The detector is only checked for performance at the 0.2 ppm level, the concentration which is legally of concern.

Reference:

+ R F D Bradshaw. Platinum Metals Review, October 1977, Vol 21, No 4.

